

## Search and rescue system

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The new generation of SAR (Search and Rescue) systems is highly secure and reliable, with embedded portable GPS (Global Positioning System) receiver. It must operate anywhere, anytime, under all weather conditions. The SAR equipment must be lightweight, of small dimensions, handheld and flexible to use with the possibility of automatic activation and operation if the survivor is injured or unconscious.

*Key words:* aircraft, airborne equipment, pilot, search and rescue, electronic equipment, beacon, radio locator.

### Introduction

THE main requirements of the SAR is to provide a rapid and successful search and rescue of aircrews. It must be easy to use lightweight and operate under extreme conditions for as long as possible.

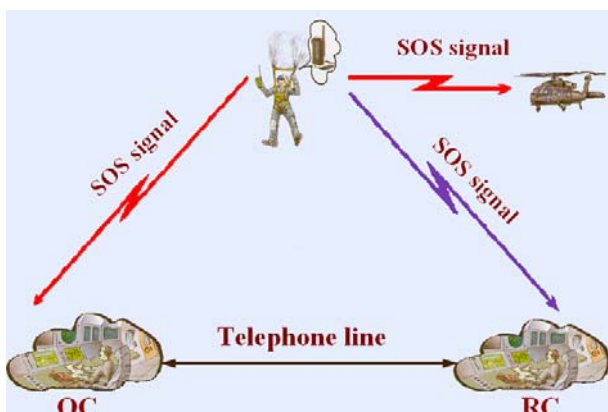
Search and rescue system consists of:

- Personal radio locator
- Portable airborne equipment
- Search and rescue center

This study is the result of a research of the possibility to equip military aircraft with optimal configuration and up to date non-combat SAR, in accordance with the worldwide standards.

### Principles of SAR operation

In situations when the pilot is parachuted to the Earth, it is necessary for him to be equipped with SAR.



OC – Operating Center, RC – Rescue Center

Figure 1. Rescue Mission for the pilot who left the aircraft

This equipment enables the rescue team to determine the location of the possibly injured downed aircrew rapidly. In hopeless situations, pilots decide to eject and from that

moment search and rescue mission starts.

Sequence of the operation, from the moment of ejecting to the moment of pinpointing the location of the downed aircrew, will be explained on the principles of operation of the AN/URT-140 and AN/PRC-149 units from Tadiran Spectralink [1], Fig.2.

System performance of non-combat SAR AN/URT-140 and AN/PRC-149, intended for application over friendly territory, is given in Table 1.

Table 1. Electromechanical characteristics of SAR

	Beacon Radio Set AN/URT-140	AN/URT-149
Primary Mission	Non-Combat SAR	
Frequency range	121,5 , 243 MHz and 406,025 MHz	
COSPAS/SARSAT Beacon	Multiple channel programmable VHF/UHF (only AN/PRC-149)	
Beacon Range	> 46 km with receiver aircraft at 300m AGL (Air-to-Ground-Level) 92 km with receiver aircraft at 3000m AGL	
Geolocation Accuracy	< 100 m with external GPS receiver	< 100 m with embedded GPS receiver
Identification	Unique and programmable ID (identification number)	
MTBF	> 2500 hours	
Environment	-40°C to +55°C operation -60°C to 85°C storage Aircraft / Carrier EMI	
Water Immersion	150 m	
Battery	72 hour life (in 406,025 MHz Beacon Mode); Field-replaceable battery Commercially available batteries	
BIT/Support Equipment	Go/No-Go BIT	
Weight	680 g	850 g
Size: wide, high, deep	6.6 x11.8 x 3.2 cm	8.9 x19.1 x 5.1 cm
Accessories		Optional: Swimmer Remote Control Unit Auxiliary earphone Voice Synthesizer
Detection		Rescue Coordination Center (RCC)

\*COSPAS/SARSAT- Russian and USA search and rescue satellite system

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The operation procedure is as follows:

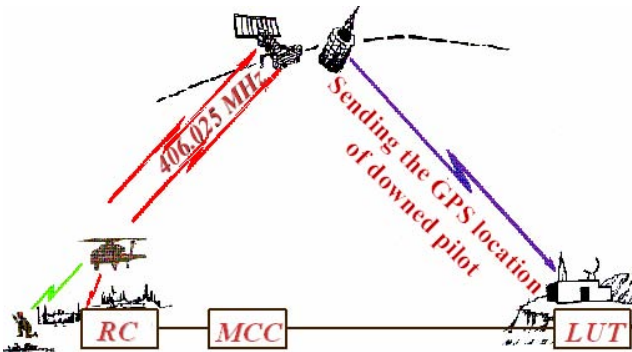
- Pilot must leave the aircraft. Upon pilot's ejection, beacon radio set AN/URT-140, mounted in the pilot's ejection seat, is automatically activated and simultaneously transmits geolocation given by airborne GPS receiver at the moment of ejection. This unit provides LOS (Line of Sight) beacon frequencies of 121,5MHz, 243MHz. In addition, an emergency signal of 406,025MHz is transmitted to COSPAS-SARSAT satellites, providing the Rescue Center with pilot's position and unique, programmable ID (Identification Code). Rescue Center alarms the aircraft embedded with SAR and provides it with the pilot's position.



Figure 2. Personal Radio Locator for the pilot and Airborne SAR

Downed pilot can:

- Let AN/URT-140 transmit emergency signal or turn it off.
- Turn on AN/PRC-149, carried in the pilot's flight suit, which starts to transmit emergency signal of each of the three emergency frequencies.
- Emergency signal is transmitted to COSPAS-SARSAT satellites and to LOS Rescue Center, Fig.3.



LUT - Local User Terminal, MCC - Mission Control Center, RC - Rescue Center

Figure 3. Search and rescue for downed crew by COSPAS-SARSAT satellite systems

If the downed pilot is unconscious, the unit mounted in the pilot's ejection seat transmits the emergency signal until the arrival of the rescue team or end of battery life.

If the downed pilot is conscious, the decision is up to him to allow the unit, mounted in the pilot's ejection seat, to transmit emergency signal or turn it off. The pilot can turn on the unit carried in the pilot's flight suit or wait for interrogations from the airborne SAR.

Unit AN/URT-140 transmits ID and its geolocation to COSPAS/SARSAT system if the unit is integrated with an external GPS receiver.

Unit AN/PRC-149 sends pilot's geolocation to COSPAS/SARSAT system.

Communication between the downed pilot and satellites in view is shown on Fig.4.

The satellite has received the emergency signal and forwards it to the nearest Local User Terminal (LUT), which sends it to the Mission Control Center (MCC), and then, on the basis of the given position of the downed pilot, to the Rescue Center (RC), which then sends a helicopter to find the pilot and rescue him.

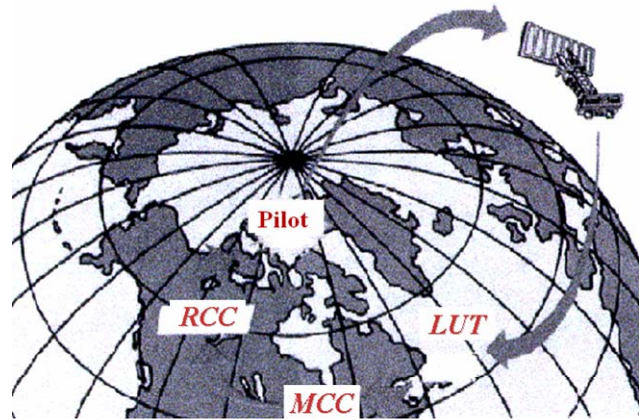


Figure 4. Satellite links with SAR centers on the Earth

### History of the development of the SAR

The sequence of development of the personal radio locator unit is:

1. The original unit consisted of the locator beacon for transmission the emergency signal till the end of battery life.
2. The emergency voice transceiver unit was added in addition to the locator beacon, with or without the transponder.
3. With the development of SAR, it became more and more certain that the pilot would be found. In addition to the locator beacon and voice transceiver with or without transponder, it was equipped with the GPS receiver, which gave his present position.
4. In time, all of these three units (locator beacon, voice transceiver, GPS receiver) were integrated into one unit.
5. State-of-the-art SAR has a unit in which are integrated locator beacon, voice transceiver and GPS receiver with transponder. It is able to transmit data of the present position to RC, directly or over the communication satellite.

A part of equipment, like locator beacon, voice transceiver and GPS receiver, are carried in pilot's flight suit. The other part, like locator beacon integrated with airborne GPS receiver, can be mounted into the ejection seat.

The development of equipment carried in the pilot's flight suit, with the development of airborne equipment, is accompanied by:

1. Locator beacon receiver, DF (Direction Finder),
2. Voice transceiver, DF
3. Voice transceiver with or without transponder, DF and GPS receiver as separate unit.
4. Integrated transceivers for locator beacon, voice communication and GPS data of the present position. The equipment must be modular and portable, and the rescue center must be equipped with receivers for pinpointing the location of the downed pilot.

### Possible configuration of the SAR

Configuration of the SAR can be realized in different variations, as shown in Table 2.

**Table 2.** Possible configurations of the SAR systems

Variants	Personal Radio Locator	SAR on the aircraft
1	Beacon	DF (Beacon receiver)
2	Beacon, Radio station for voice communication	DF, Radio station for voice communication
3	Beacon, Radio station for voice communication, GPS receiver	DF, Radio station for voice communication, GPS receiver
4	Beacon, Radio station for voice communication and sending data about the position of the pilot, GPS receiver	DF, Radio station for voice communication receiving the data about the location of the downed pilot, GPS receiver
5	4. variant with the possibility of sending data location of the downed pilot via satellite	4. variant with the possibility of bidirectional communications through satellite

First variant of the SAR system contains only the DF receiver on the SAR aircraft. This equipment enables determination of the direction of the downed crew, along the airborne center line. In case when the location of the crash landing is unknown, it may not be possible to obtain the DF information. The reason for that is a short range of the beacon and/or the configuration of the terrain in the vicinity of the downed crew.

The second variant of the SAR system is somewhat better from the first, because it makes possible to determine the location direction of the downed crew and communicate with them if they are alive. This SAR system does not give accurate geolocation of the downed crew which makes the rescue mission more difficult, especially on the enemy territory. If survival radio transmits data messages from the survivor to the rescue team along with its associated interrogator unit, the rescue team can obtain information from the radio without the operator having to physically send the message and therefore spares the battery life. The third variant provides in addition an accurate geolocation of the downed crew-circular error position (CEP) up to 100m. It is common for this piece of equipment to have the responder and transmit data message from the interrogator unit. The fourth variant has the same functions as the third, but all the units are integrated into one light weight unit.

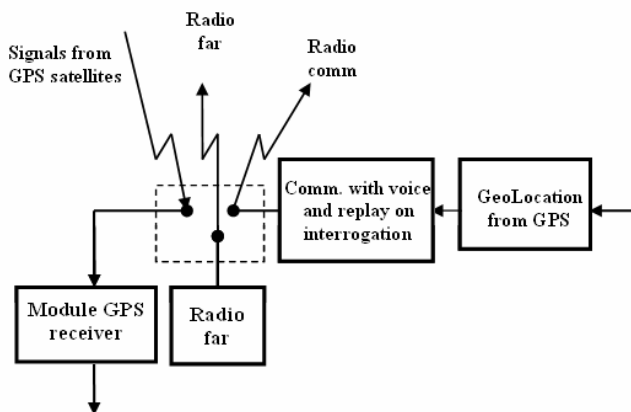
The fifth variant is allowed only for the NATO members or under NATO permission.

Block scheme of the fourth configuration from Table 2 is shown in Fig.5.

This configuration provides:

- Rapid pinpointing the location of the downed crew,
- Rendezvous, pick-ups of the rescue team, drop-zone marking and

It is the most advanced system of its type currently available in the world market.

**Figure 5.** Block scheme of the configuration number 4 from Table 2

This solution is intended for non-combat use, but its architecture is suitable for implementing safe communications for wartime application.

## Review of the existing equipment in the world

### Personal Radio Locator, SAR equipment for the pilot

Motorola (USA) [2], Tadiran (Israel) and Becker (Germany) [3] Companies, developed a whole set of units which enables location of the downed crew.

The **PRC-90-2 (Motorola)** is a compact, rugged, hand held system designed for tactical air to ground/ground to ground communications in two-way AM voice or beacon operation on 282,8MHz or on 243,0MHz, in non-combat and combat application. The unit operates as radio beacon on the frequency of 243,0MHz.

**PRC-106-2 (Motorola)** is an advanced version of PRC-90-2. This handheld emergency voice transceiver is at the same time a beacon. It functions on both 121,5MHz and 243,0MHz, providing two-way communication: voice and beacon operation.

**AN/PRC-112 (Motorola)** is a small, hand-held transceiver that provides bi-directional voice communication and secure transponder identification, as well as navigation aid for precise location of the downed air crews. When combined with an interrogator-equipped avionics system, locations can be accurately determined with the data of bearing and in range up to 185,2km.

The **HOOK-112 (Motorola)** radio unit integrates a GPS receiver into AN/PRC-112 and provides:

- calculation of its own location by GPS satellite signals and then relaying the information to the interrogation from SAR aircraft via any voice channel of AN/PRC-112 V/UHF frequency, (automatic, in case when the survived pilot is injured or unconscious),
  - encryption protection for all communications (voice, location, ID and messages),
  - voice and beacon signals on VHF 121,5MHz and UHF 243MHz,
  - distance measuring equipment transponder and
  - capability for handling multiple users with distinct IDs and encryption codes.
- Civil version GPS receiver with C/A code provides:
- position location (with accuracy of 100m)
  - plot GPS location coordinates, on maps which are already carried in, by using global latitude and longitude or the local area and
  - tracks rendezvous points while processing two-way message data bursts.

The **Motorola GPS-112** combines beacon, transceiver, transponder and GPS receiver into a single, handheld radio with the capacity for sending the GPS position. Based on field-proven AN/PRC-112 and PRC-112B (HOOK-112), it sends encrypted global positioning in one way and two-way messaging. Standard format data of position, latitude, longitude, UTM (Universal Transverse Mercator) or military grid System (MGRS) coordinates are communicated in one short burst to the CSAR airborne. The unit GPS-112 responds to either a specific identification code or to an "all call" interrogation. GPS receiver calculates position with the accuracy of up to 25m.

The GPS position sent in one short burst on any AN/PRC-112 V/UHF frequency, which is a part of GPS-

112. Transmission of the burst data is encrypted. The receiver on the aircraft unpacks the data by advanced algorithm with allowed FEC, forward error connection.

The DME, Distance Measuring Equipment, is embedded in GPS-112 measuring the distance from the downed pilot to the SAR on the aircraft. Distance information is sent along with other interrogation data from the other aircraft.

It retains all of AN/PRC-112 characteristics, low power consumption and features flexible power source capabilities. The GPS-112 has pocket-size, light-weight design and easy for handheld. Module of GPS receiver has 12-parallel channel, with C/A code and storage memory for up to 250 navigational waypoints. Unit GPS-112 is equipped with low/light enhanced back-lit display and keypad. Voice communication and beacon are the on VHF frequency of 121,5 MHz or UHF frequency of 243,0 MHz.

The **AN/URT-140** and **AN/PRC-149 (Tadiran Spectralink)** are intended for use in non-combat SAR missions. The principle of operation of modern SAR for downed pilots will be explained on the bases of these units.

**PRC-434A** and **PRC-434G (Tadiran Spectralink)** are handheld transceivers which are a part of ASARS and its modern version, ASARS-G.

Unit ARS-700 is a part of this system and is embedded in the aircraft or helicopter.

System ASARS has the following properties:

- up to 200km operational range with high accuracy of 50m and 360° direction finding capability with accuracy of 5° root mean square (rms).
- 20m final approach accuracy.
- Secure short-burst interrogation (0,6s) is enough to locate the pilot, who left the downed aircraft.
- If the survivor is injured or unconscious the unit PRC-434A (PRC-434G) can be automatically and remotely activated by the system's airborne units.

System ASARS-G maintains all existing ASARS features and has additional new features:

- Provides geographical coordinates of GPS position.
- Secure data channel at all available frequencies for transmission, reception and relaying of the present position, route, and waypoints, pick-up location and pre-scanned messages and
- Remote activation of embedded GPS receiver by the airborne units.

Operation of **MR 509 (Becker)**, Personal Locator Beacon is initiated manually or automatically. When activated, the unit transmits an intermittent, sweep tone radio distress signal in the UHF/VHF aviation frequency bands and messages on the COSPAS/SARSAT satellite frequency. Transmission is omni-directional and continuous for at least 24 hours at 0°C to facilitate detection by satellite, aircraft or vessels, or by any other land, sea or airborne installation monitoring these frequencies.

**CSEL (Combat Survivor Evader Locator)** is a communication system which provides the downed aircraft's crew with: geoposition coordinates, two-way over-the-horizon (OTH) secure data communication to the SAR Center, Line Of Sight (LOS) voice communication and OTH beacon operation.

The new Combat Survivor Evader Locator, CSEL is composed of three segments:

- Satellite over-the-horizon, OTH
- Ground and
- Personal Radio Locator Unit for the downed aircrew or pilot.

Tables 3 and 4 present technical characteristics of the SAR units for the pilot.

**Table 3.** Technical characteristics of the SAR units for the pilot

Performanse. Unit	Country	Weight (kg)	Beacon Frequency (MHz)	Battery life
PRC-90-2	USA		282.8, 243	
PRC-106-2	USA		121.5, 243	
AN/PRC/112	USA	0.794	121.5, 225-229.975	12 hours
HOOK-112	USA		121.5, 225-229.975	
GPS-112	USA	0.963	121.5, 225-229.975	
AN/URT-140	Israel	0.68	121.5, 225-229.975	72 hours
AN/PRC-149	Israel	0.85	121.5, 225-229.975	
MR 509	Germany	0.76	121.5, 225-229.975	24 hours
PRC-434A	Isreal		121.5, 225-229.975	15h, 25h
PRC-434G	Isreal		121.5, 225-229.975	15h, 24h
CSEL	USA			21 days

**Table 4.** Technical characteristics of the SAR units for the pilot (continued)

Character. Unit	Radio far	VHF/UHF voice	Transponder	GPS	DME reply	COSPAS/ SARSAT
PRC-90-2	*	*				
PRC-106-2	*	*				
AN/PRC/112	*	*	*		*	
HOOK-112	*	*	*	*	*	
GPS-112	*	*	*	*	*	
AN/URT-140	*	*	*			*
AN/PRC-149	*	*	*	*		*
MR 509	*	*	*			*
PRC-434A	*	*	*			
PRC-434G	*	*	*	*		
CSEL	*	*	*	*		*

#### *Equipment for Search and Rescue on the aircraft*

The **ARS-700 and ARS-700G (Tadiran Spectralink)** embedded on the aircraft or helicopter consist of:

- Aircraft unit,
- Control and display unit ,
- Antenna switch and Antenna.

The ARS-700 and modern version ARS-G, Airborne Interrogator and Guidance system, utilizing range and direction data, interrogate the PRL and obtain survivor's location, relative to the aircraft/helicopter heading. This data is displayed on the Control and Display Unit.

**SAR-ADF 517 (Becker)** is automatic Aircraft Direction Finder for search and rescue receiving signals on frequencies of 121,5MHz, 243MHz and 156,8MHz (channel for navy). The unit transmits digital pulse with the duration of 450ms, every 50s using a new frequency of 406,025MHz to the satellites COSPAS/SARSAT systems. Traditional ADF systems rely on a continuous swept tone from the beacon to ensure reliable homing, but the digital pulse from 406MHz beacons is too brief for the ADF to secure a lock.

Unit SAR-ADF 517 can be selected to automatically cover the 49,5s lapse time between two digital pulses.

The hardware of the system is composed of control unit and display unit connected to a remote antenna mounted on the underside of the aircraft.

The comparison of characteristics of the SAR aircraft equipment is given in Table 5.

**Table 5.** Technical characteristics of the SAR systems on the aircraft

Characteristic	Unit	
	ARS-700	SAR-ADF 517
Power	10 A, 10V DC	12-32 V DC
Frequency ( MHz )	225-299,975	121,5; 123,1; 243,5; 245,1; 406,25
COSPAS/SARSAT		*
Sensitivity	-103 dBm	5 $\mu$ V/m

### Conclusion

The purpose of the SAR system is precise and fast detection of the location of the downed crew or crew who

had a collision with another aircraft, but not to endanger the safety of the rescue team and downed crew.

The need for this kind of equipment resulted from the extensive hands-on experience of the air forces of other countries who dedicated a significant amount of attention to this problem.

On the Earth, the SAR system needs wide logistic support.

### References

- [1] [www.tadiran-spectralink.com](http://www.tadiran-spectralink.com)
- [2] [www.fas.org/man/dod-101/sys/ac/equip/hook-112.htm](http://www.fas.org/man/dod-101/sys/ac/equip/hook-112.htm)
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SRS – Search and Rescue System

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## Oprema za traganje i spasavanje pilota

Brzi razvoj elektronskih sistema uticao je na razvoj opreme za traganje i spasavanje (OTS) posada prisilno prizemljenih aviona, sa kojom su opremljeni piloti i spasilačke ekipe. Ova oprema mora biti malih dimenzija, laka i jednostavna za rukovanje, sa mogućnošću automatskog aktiviranja i funkcionisanja u ekstremnim ambijentnim uslovima. U radu su opisane funkcionalne karakteristike i konfiguracije OTS koja je u upotrebi u svetu.

*Ključne reči:* letelica, oprema letelice, pilot, spašavanje posade, elektronska oprema, radio-far, radio-lokatora.

## Оборудование для поиска и спасения лётчиков (экипажа)

Быстрое развитие электронной системы влияло и на развитие оборудования для поиска и спасения лётчиков (экипажа) самолётов со принужденной посадкой, которой снабжены лётчики и спасательные команды. Это оборудование должно быть маленьких размеров, лёгким и простым для манипулирования, с возможностью автоматического привода в действие и функционирования в крайних условиях окружающей среды. В настоящей работе описаны функциональные характеристики и конфигурации оборудования для поиска и спасения экипажа, которое пользуется в мире.

*Ключевые слова:* летательный аппарат, бортовое оборудование, лётчик, спасение экипажа, бортовая электронная аппаратура, радиомаяк, радиолокатор.

## Équipement pour la recherche et le sauvetage des pilotes

Le développement rapide des systèmes électroniques a influencé sur le développement de l'équipement pour la recherche et le sauvetage (OTC) des équipages des avions atterrissés par force et dont les pilotes et les équipes de sauvetage sont équipés. Cet équipement doit être de petites dimensions, léger et facile à manipuler, avec la possibilité d'être activé dans les conditions extrêmes d'ambiance. Dans ce papier on a décrit les caractéristiques fonctionnelles et les configurations du OTC qui est utilisé actuellement dans le monde.

*Mots clés:* aéronef, équipement de l'aéronef, pilote, sauvetage de l'équipage, équipement électronique, radiophare, radio marqueur.